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TITLE: APPLICATION OF PICOSECOND CO_2 LASERS TO PARTICLE ACCELERATORS

AUTHOR(S): Irving J. Bigio
Norman A. Kurnit
Tsutomu Shimada
Robert F. Harrison

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Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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Irving J. Bigio, Norman A. Kurnit,
Tsutomu Shimada and Robert F. Harrison
Los Alamos National Laboratory
MS-J566, Los Alamos, New Mexico 87545
(505) 667-6448

ABSTRACT

Various advanced accelerator concepts invoke lasers for the generation of very-high-gradient accelerating fields. We introduce the subject and review the application of picosecond CO_2 lasers to one such scheme: laser-driven open microstructures.

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SUMMARY

Future generations of particle accelerators for high-energy physics will produce lepton energies in the range of 10 TeV and will require much higher accelerating gradients than can be made available from extrapolations of current technology. Various schemes have been proposed that utilize the the very large electric fields available from focused short-pulse lasers. Whereas existing RF accelerator devices provide gradients of 10 MeV/meter, and extrapolations utilizing superconducting structures are expected to yield 100 MeV/meter, laser-driven schemes appear to be capable (at least theoretically) of gradients exceeding 10 GeV/meter.

However, laser-driven particle accelerators will have specifications that demand laser capabilities beyond what is currently available. Proof-of-principle demonstrations notwithstanding, the ultimate practicality of any of the schemes may well depend on the realities of laser development. It is interesting to note therefore that, in projecting from the laser requirements of a demonstration experiment to those of a scaled system, probably fewer "leaps of faith" are required in the case of one such scheme - laser-driven open structures - than for many of the other currently proposed concepts. The fact that open structures can potentially be used

as powerful focusing or bending elements,[1] wherein power-conversion efficiency is essentially unimportant, also adds attractiveness to the scheme.

Table I lists the laser specifications as required by the initial demonstration experiments and also as envisioned for a replicated subunit of a scaled accelerator system. It should be noted that since many of the specifications of an imagined future-generation accelerator are not well defined, some of the laser specifications are consequently nebulous. Nonetheless, the intent is to bolster the argument that we already have a technology base from which to extrapolate future development.

	Initial Experiments	Longer-range Requirements
λ	10 μm	10 μm ? longer ?
E	10 - 100 mJ	≥1 J (depends on staging)
Δt	1 - 5 ps	1 ps
BQ	near diff. lim.	near diff. lim.
PRF	1 Hz	PRF of the accelerator (limit ~1 kHz)
ΔT	1 - 5 ps	1 ps
η	unimportant	≥10%

Table I. Comparison of short-term and long-term laser requirements. (Δt ≡ pulse duration, BQ ≡ beam quality, PRF ≡ pulse repetition frequency, ΔT ≡ synchronization jitter wrt accelerator pulse, η ≡ efficiency.)

In the case of the requirements for the initial experiments, all of the specifications can either be met or exceeded by the system currently under construction.

Moreover, viable techniques to generate the critically specified short CO_2-pulse duration have already been demonstrated by others.[2] The most difficult specifications to extrapolate to future requirements are the PRF (with good beam quality) and the efficiency, η, especially if the requirements exceed 1 kHz and 10% respectively. Both of these requirements are readily within theoretical limits, and the predominant issues are ones of engineering development. However, such engineering is involved and would require a significant investment. Nonetheless, it is refreshing to note that extrapolation to as-yet unconceived lasers is not required.

The system under construction for a proof-of-principle demonstration will be described, and the various advantages and disadvantages that lasers bring to such schemes will be discussed.

REFERENCES

1. R.B. Palmer et al., in *Laser Acceleration of Particles*, (Am. Inst. Phys., 1985) p.234. Norman M. Kroll, *ibid*, p.253.

2. P.B. Corkum, Opt. Lett. **8**, 514 (1983).